1 Assignment 8 (100 points)

To submit your work, collect your inputs not provided as part of the assignment, the required outputs, and your answers to the written questions in pdf format (preferred) or Word, or .txt . Clearly label all of your work. For the math-oriented portion of the assignment, you may typeset in LaTeX or Word or provide a clear photograph of a hand-written solution. Work that is not legible will not be graded. Name a zip file `CS585_Assignment8_username.zip` and submit with web-submit. Collect your .cpp files and label code that you changed with comments containing your username like: `//Modified by wenxinf`

1.1 Learning Objectives

- Gain familiarity with Optical Flow
- Gain familiarity with Background Modeling
- Prerequisites for Multiple Hypothesis Tracking

1.2 Technical Task (100 points)

For this assignment, we will simply practice making some calculations using the optical flow field computed by OpenCV. For extra credit, you can write a program to perform background subtraction based on one of the OpenCV tutorials.

1. Given: Skeleton code to read from a video file, compute the optical flow and visualize the flow field.
   The provided skeleton code can read from either the camera or a video file. If you would like to use a sequence of PNGs, you can copy the necessary code from HW7.
2. Required: Given the flow field, calculate the magnitude and orientation of the flow vectors by filling in the function `opticalFlowMagnitudeAngle.` Example Output is provided in the zip file for the homework. You should capture a video of your own and submit your output images for five consecutive frames. I recommend using a recorded video rather than the live video because the provided implementation is not very efficient.
3. Given: Skeleton code to visualize the magnitude and orientation of the flow field
4. Extra credit: This OpenCV tutorial did not work for me out-of-the-box: `http://docs.opencv.org/trunk/doc/tutorials/video/background_subtraction/background_subtraction.html`. You can modify this example or you can write your own program to perform background subtraction using one of the background models we discussed in class on Thursday. Submit five consecutive images showing the original video and the segmented video from a video that you have created or from a video or image sequence from one of the many surveillance data sets available. (There is one database linked from the page for the tutorial.)

1.3 Lecture Preparation (50 pts)

The week after next, we will cover multi-target tracking with multiple hypothesis tracking

1. Briefly describe what a Linear Program is. (The example on `http://en.wikipedia.org/wiki/Linear_programming` is helpful.)

2. Briefly describe the difference between a linear program and an integer program. `http://en.wikipedia.org/wiki/Integer_programming`.

3. Pretend that you are tracking some objects in your video. In each of three consecutive frames, you have two detections, $\{x_{1,1}, x_{1,2}, x_{2,1}, x_{2,2}, x_{3,1}, x_{3,2}\}$ (first index for time and second index for detection ID.) Your goal is to determine which detections should go together to make your tracks.

   (a) Draw two trees showing all the possible associations between the detections. For the first layer, you should have one tree where $x_{1,1}$ should be connected to both $x_{2,1}$ and $x_{2,2}$, and a second tree where $x_{1,2}$ is also connected to $x_{2,1}$ and $x_{2,2}$.

   (b) Write an alternative representation of the set of possible associations using a matrix, A. Each row of the matrix corresponds to one variable ($\{x_{1,1}, x_{1,2}, x_{2,1}, x_{2,2}, x_{3,1}, x_{3,2}\}$). Each leaf of your tree corresponds to one column of the matrix, where the entries in the column are 1 if the detection is included in a path from the root of the tree to the leaf, and 0 if it is not.

   (c) Choose two leaves from your trees so that the paths from the roots to the leaves do not share any detections. For example, two paths could be $\{x_{1,1}, x_{2,1}, x_{3,2}\}$ and $\{x_{1,2}, x_{2,2}, x_{3,1}\}$. Represent your choice of two leaves with a selection vector X. The vector should have a 1 corresponding to the two tracks you chose and a zero everywhere else.

   Show that if you choose two non-overlapping tracks, then the result of Ax is a column of ones. Show that if you choose two overlapping tracks (where a detection is shared between the tracks), then Ax will contain one or more entries that are zero and one or more entries that are greater than one.